パイン葉サイレージに関する研究 : I 化学的特性について(畜産学科)

Studies on the Pineapple Leaf Silage[1]

I. Chemical Properties

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I INTRODUCTION

It is well recognized that pineapple leaves can be used as a roughage for both beef and dairy cattle in a form of pelleted hay or silage as well as green forage (2, 8). Stanley and Morita (8) pointed out that dairymen would be able to feed up to 28 kg of pineapple silage per head daily without adversely affecting milk production or composition. The value of pineapple cannery pulp for dairy cattle and swine has been reported by Miyagi (3, 4). Also, technical know-how for ensiling pineapple leaf silage was introduced to the farmers in Okinawa by the livestock specialists from Hawaii, U. S. A.

Approximately 50 to 100 tons of leafy by-product can be produced from one hectare (2). As 5,637 ha of the land is utilized for this crop (1969－1970), 56,350 to 112,700 tons of the material would be available for silage every year if one-fifth of the field is renewed for new plants.

In spite of the fact that pineapple leaf silage is a potential source of a roughage for cattle in Okinawa, no informations concerning the precise chemical properties of this preserved feed are available. Hence, it is very important to conduct a fundermental research for this silage and the original materials, which otherwise are presently going to waste causing the extra labor for disposing it, and to solve or lessen the issue of the high feed cost on these islands where the land is limitted for the pasture.

This experiment was carried out to clarify the characteristics of pineapple leaves (shoots, hapas and slips), pineapple cannery pulp and sugar cane molasses as ensiling materials or additives and to evaluate the resulting silages by examining the variables such as proximate nutrient, recovery of the material ensiled, pH value, total N, NH_3－N, NH_3－N／total N, carotene and organic acid contents.

[1] Supported in part by the Scientific Research Grant from the Japanese Educational Ministry

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Sci. Bull. Coll. Agr. Univ. Ryukyus, **22**: 343～351 (1975)

II MATERIALS AND METHODS

Pineapple plants mainly composed of shoots, hapas and slips which were obtained from a pineapple farm at Gogayama, Nakijin village in August, 1974 were used. These materials were cut into pieces of approximately 20㎝ in the field before being carried to the Livestock Division of Agricultural Farm of the University of the Ryukyus. These pre-cut materials were bruised and chopped with a harbage chopper. For the establishment of the high dry matter content, they were laid on the concreate floor. As some molting spots were detected due to the high humidity, the drying process was quitted after 24 hours. Eventually the prepared materials contained 85 to 88 % moisture.

The experimental design and the amount of the silage obtained are presented in table 1.

Table 1. Experimental plan and amounts of silages obtained

Silage No.	Material ensiled (㎏)			Period (days)	Silage Produced (%)
	Leaf	Pulp	Molasses		
1	20	–	–	55	14.67
2	15	5	–	55	15.40
3	19	–	1	55	16.15

Polyethlene bags (0.2 ㎜ thick, 45 ㎝ wide, 90 ㎝ high) were used as silos. Pineapple cannery pulp was squized by hands to reduce the water content. Molasses without dilution was sprayed over the leaves and mixed completely before ensiling into the bags. The bags were closed thight and fast with rubber tube and the air was withdrawn by a vacuum pump. Two bags containing 20 ㎏ materials for each experimental treatment were prepared. From each bag pairs of samples for the determination of the criteria were collected. The bags were preserved in the laboratory where the average room temperature was 28 ℃ in the day time while it became higher at night due to the enclosing of the room. As several white molting spots were observed after 19 day ensiling in the silage (No. 3), the bags were vacuumed again with 210 g seepage. This treatment could not eliminate them. No vacuuming thereafter was employed since these spots did not spread farther.

The proximate analysis was conducted by applying the conventional method of A. O. A. C. Beckman-Toshiba pH meter (Lab-O-Mate) attached with glass electric rods was used for pH determination. Contents of lactic acid and carotene were estimated by using Hitachi-Perkin Elmer spectrophotometer. Total nitrogen was determined by the method of Kjeldahl, while Cornway's micro diffusion technique was adopted for the volatile basic ammonia (VBA) determination. To grade the silages produced lactic, acetic and butyric acids were measured by the method of Flieg as described by Morimoto (5). The data obtained were not treated statistically.

III RESULTS AND DISCUSSION

The results involving the recovery of the ensiled material are presented in table 2.

Table 2. Recovery of the ensiled material, losses in seepage and others(%)

Silage No.	Recovery	Loss in seepage	Loss other than in seepage	pH
1	73.35	14.50	12.50	4.41(4.39)*
2	77.00	13.40	9.60	4.02(4.02)
3	80.75	12.50	6.25	3.75(3.85)

* Figures in the parentheses are pH values in seepage

The silage (No. 3) with 5% sugar cane molasses showed the highest recovery (80.75%) being followed by the silage (No. 2) with 25% pineapple cannery pulp (77.00%) and the silage (No. 1) with no additives (73.50%). As for seepage loss, on the other hand, the lowest (12.50%), the intermediate (13.40%) and the highest (14.50%) values were observed in the silages (No. 3), (No. 2) and (No. 1), respectively. Also the losses due to fermentation and respiration (losses other than seepage) were 6.25%, 9.60% and 12.50% for the silages (No. 3), (No. 2) and (No. 1), respectively. Although pH values of the seepage were higher than those of extracted liquid from the silage materials, the trend was similar being the lowest for the silage (No. 3), intermediate for the silage (No. 2) and the highest for the silage (No. 1). It is generally well known that application of the substances high in carbohydrates, which are used as energy sources for the useful microorganisms, results in a higher recovery of the ensiled materials with lower pH and losses because of the fermentation and respiration, and the seepage (6,7,9). The present work is agreeable with these reports in this respect. From a stand point of pH value, the silage (No. 3) can be classified as an excellent silage (10, 11). Also the values for the other two silages are slightly higher than the maximum level of pH 4.0 to be an excellent one.

Table 3 presents the proximate nutrients of pre-ensiling materials, fermented silages and soluble carbohydrate contents determined colorimetrically.

Table 3. Proximate nutrients of ensiling materials and resulting silages (%)

Silage No.	Moisture A[a]	Moisture B[b]	Crude protein	Crude fat	Crude fiber	Crude ash	NFE	Soluble carbohydrate[c]
Material								
1	87.5	–	1.3	0.4	3.1	1.2	8.0	11.82
2	87.0	–	1.3	0.4	3.2	1.1	8.5	10.32
3	85.0	–	1.6	0.4	3.1	1.8	9.5	23.32
Silage								
1	86.8	84.3	1.3	0.6	4.2	1.4	5.7	2.69
2	87.0	84.7	1.4	0.7	4.1	1.2	5.7	4.28
3	84.4	82.5	1.8	1.1	3.8	2.0	6.9	4.26
Molasses								
1	22.0	–	3.0	–	–	8.6	66.0	–

[a] Conventional method; [b] Using toluene; [c] Colorimetrically

Addition of molasses slightly increased the contents of crude protein, crude ash and nitrogen free extract while decreased moisture content before ensiling. Similar results were obtained for these variables in the silage samples. The high moisture contents (85.0 to 87.5 %) of these silages show that drying was not complete. Consequently they are classified as high moisture silage (12). Preservation of the materials for 55 days decreased crude fat and NFE contents while increased the amounts of crude fiver, crude ash and crude protein. The reason for the decrease in the former two criteria must be the consumption of these substances by the microorganisms and fermentation as well as the respiration. Although the increase in the latter two variables seems to be attributed to the consumption of soluble substances in such manner and to the losses in the seepage resulting in a higher fiber and mineral contents, the reason for the increase in protein is not clear in the present experiment. As the data were not treated statistically, the differences may be within the normal range of the deviations. It is interpreted that higher soluble carbohydrate contents by the colorimetrical determination are due to the pigments of the solution in the silages, especially to the color of the molasses showing a tremendously high value of 23.32 %. Therefore it is suggested that a very careful attention be paid to the colorimeterical determination of criteria for the silage materials containing the substances which might affect the absorbance of the solution extracted from thess materials.

The effects of the cannery pulp and molasses on the total N, NH_3-N, NH_3-N/total N, and carotene contents are shown in table 4.

Table 4. Effect of pineapple cannery pulp and sugar cane molasses on nitrogen and carotene contents

Silage No.	Total N (mg)	NH_3-N (mg)	NH_3-N / total N (%)	NH_3-N in seepage (mg)	Carotene* (%)	Carotene retained (%)
1	214.4	36.6	17.1	30.4	0.32	38.44
2	230.4	42.4	18.2	33.2	0.23	30.22
3	284.4	37.0	13.0	30.7	0.54	67.49

* The carotene content of the original pineapple leaf was 0.84 mg % ; pineapple pulp 0.05 mg %

The silage (No. 3) resulted in the highest total N (284.4 mg) and the lowest NH_3-N (37.0 mg), eventually with the lowest NH_3-N/total N (13.0%). The silage (No. 2) was the highest in NH_3-N (42.4 mg) and NH_3-N/total N (18.2 %) with the intermediate total N (230.4 mg). In seepage, the highest NH_3-N content (33.2 mg) was also found in the silage (No. 2). These results indicate that pineapple cannery pulp contains a certain substance which reduces the preservation of protein. Farther research must be conducted to detect the specific substance ivolved here. Although the silage (No. 3) produced 30% more total N compared to the silage (No. 1), no differences were obtained in NH_3-N determned in both the silage extract and the seepage between two kinds of silages. This result may indicate that the balance (70 mg) existing between total nitrogens of the silages (No. 1) and (No. 3) is another nitrogen form than NH_3-N, probably amino N. Published evidence is definite that the addition of carbohydrate decreases the production of NH_3-N value and increases the retention rate of carotene (6, 9). In this experiment, application of 5% sugar cane molasses raised the carotene content from 0.32 mg % to 0.54 mg % resulting in approximately 30 % improvement. On the other hand, use of pineapple cannery pulp decreased this value. This seems to be attributed to the low carotene content of the pulp added to the silage.

Amounts of total organic acid, lactic, acetic and butyric acids determined by Flieg's method are given in table 5. Also, lactic acid values colorimetrically measured are presented in this table. No silages produced butyric acid. The silage (No. 3) with cane molasses, which gave the highest total organic acid (3.61 %), lactic acid (2.84 %) and the lowest acetic acid (0.77%), marked 97 points and was classified as an excellent one according to Flieg's method. Although the silage (No. 2) was fairy high in total acid, its point was only 58 due to a very high acetic acid. The silage (No. 3) was the lowest in lactic acid and evaluated poor with 56 points. These results are in agreement with those of others who mentioned that addition of carbohydrates increascd the amount of lactic acid and resulted in a higher quality of silage (4,8,11).

Table 5. Effect of additives on the organic acid contents (%)

Silage №	Extract of silage					Seepage*					Lactic acid by colorimeter
	Total acid	Lactic acid	Acetic acid	Butyric acid	Point	Total acid	Lactic acid	Acetic acid	Butyric acid	Point	
1	2.50	0.91	1.59	0	56	26.83	8.42	18.41	0	53	0.94
2	3.43	1.45	2.03	0	58	35.32	14.77	20.55	0	58	0.37
3	3.61	2.84	0.77	0	97	25.83	17.64	8.20	0	83	3.45

* Dense seepage solution was used without dilution

However, it seems 25 % of wet pineapple cannery pulp is not enough to raise the value of the criterion and its quality. Similar trend was obtaind in the seepage solution though the points in the latter were higher because of the dense solution. It is interesting to note that the silage(No.2) showed the highest total and acetic acids in the seepage in contrast to the silage extract indicating a specific mechanism to be involved here. Lactic acid contents determined by both Flieg's and the colorimeterical methods were similar in trend. However, the latter method gave significantly lower value (0.37%) compared to the former method (1.45%).

Considering all the results discussed so far, it can be suggested that in addition to molasses other types of carbohydrates, which simultaneousely decrease the moisture content of the pineapple leaf, and the preservatives such as acids or antibiotics be attempted for further improvement of this preserved feed. Research concerning such treatments will be reported elswhere in future.

IV SUMMARY

Three kinds of pineapple leaf silages were prepared : 1) the silage (No. 1) with no additives, 2) the silage (No. 2) with 25% wet pineapple cannery pulp and 3) the silage (No. 3) contaning 5% sugar cane molasses. To study the fundermental chemical properties of these silages, criteria or variables such as the proximate chemical composition, recovery of the ensiled materials, pH, total N, NH_3-N, NH_3-N/total N, carotene and organic acid contents as well as the grade by Flieg's method were determined. Under the conditions of this experiment, the following summary appears justified:

1. All silages resulted in low dry matter contents. Pineapple leaf material should be dried more to reduce the moisture content before ensiling and to improve the quality.

2. Twenty five percent wet pineapple cannery pulp in the silage as additive was not enough to supply energy for microorganisms to enhance the production of lactic acid and the improvement in the preservation of nitrogen and carotene.

3. Application of 5% sugar cane molasses seemed to be a practical way and resulted in higher material recovery and carotene preservation and low NH_3-N fermentation and pH value.

LITERATURE CITED

1. Koja, Z. 1960 Pineapple cannery pulp silage. Farm and Home Extention, University of the Ryukyus, **51** : 2～10

2. ________. 1965 Pineapple leaf silage. Farm and Home Extention, University of the Ryukyus, **115** : 8～9
3. Miyagi, T. 1960 Studies on the utilization of pineapple pulp as feeding stuff. I. Studies on feeding value of pineapple silage for hog. The Science Bulletin of the Division of Agriculture, Home Eonomics and Engineering, University of the Ryukyus, **7** : 398～407
4. ________. II. On the effectiveness of pineapple ensiled with urea as feed for milking cows. The Science Bulletin of the Division of Agriculture, Home Economics and Engineering, Universtiy of the Ryukyus, **7** : 408～413
5. Morimoto, H. 1971 Nutritional experiment methods for livestock. lst ed., 419～421, Tokyo, Yokendo
6. Ohyama, Y. and Maski, S. 1968 Studies on various factors affecting silage fermentation. I. Effects of soluble carbohydrates and protein on the quality of silage, Jap. J. Zootech. Sci., **39**(2) : 319～325
7. ________. and Inoue, S. 1968 Effect of molasses feed addition at ensiling to reduce nutrient losses during ensilaging, Jap. J. Zootech. Sci., **39**(7) : 61～67
8. Stanley, R. W. and Morita, K. 1966 An evaluation of pineapple silage for dairy cattle. Technical progress report, 150, HAES, University of Hawaii
9. Suto, H. 1966 Additives for excellent silage and their effects. Research in Livestock, **20**(9) : 58～62
10. ________. 1967 Recent researches on silage, Jap. J. Zootech. Sci., **38**(6) : 233～244
11. ________. 1970 Silage and hay. lst ed., 153～156, Tokyo, Yokendo
12. Ibid., 3～4

パイン葉サイレージに関する研究

I　化学的特性について

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要　　約

パイン葉（shoots, hapas and slips）を材料とする3種類のサイレージ，すなわち，1）パイン葉のみの区，2）生パイン粕25％添加区，3）糖密5％添加区の3区を設け沖縄における未利用粗飼料資源であるパイン葉のサイレージとしての栄養価値を検索する目的で化学的特性についての基礎的実験を行ない，次の知見を得た。

1）いずれのサイレージも乾物量が少なく高水分サイレージであり，その品質の向上には予乾の必要性が指摘された。

2）生パイン粕25％程度の添加では微生物の栄養源としての可溶性炭水化物含量を増加させるには不充分のようであった。すなわち乳酸の生成，カロチンおよび全N含量の増加には影響がなかった。

3）しかし，糖密を5％添加した場合には乾物の回収率，全Nおよびカロチン含量が増加し，逆にアンモニア態Nの生成とPH価は減少し品質の良いサイレージが調製された。

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